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ABSTRACT

The primary purpose of this study was to investigate the various characteristics of successful and less successful students and to determine what effect these characteristics have on achievement in an individualized learning program. Variables considered were: (1) attitudes, (2) motivation, (3) understandings about science, (4) personality, (5) scholastic ability, and (6) the ability to think critically. This study utilized responses from 406 students enrolled in an individualized learning biology program in a northern Chicago suburb. Utilizing a random sample of 25 percent of the population, a multiple regression equation was developed which was used to obtain a prediction equation in which achievement was the criterion measure. The results reveal that the "high" and "expected" achievers, in contrast to "low" achievers, had (1) a greater ability to think critically, (2) a more conscientious attitude toward school, and (3) they were more resourceful and self-sufficient, as they preferred making their own decisions. It was also found that the "high" achievers, in contrast to both the "expected" and "low" achievers, (1) had a greater interest in school activities, and (2) had a tendency to be less adventurous. (Author/BR)

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AN EVALUATION OF STUDENT CHARACTERISTICS AS RELATED TO COGNITIVE ACHIEVEMENT IN AN INDIVIDUALIZED HIGH SCHOOL BIOLOGY PROGRAM

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An Evaluation of Student Characteristics as Related to Cognitive Achievement in an Individualized High School Biology Program

One of the techniques that is increasingly being used in the teaching of science is that of individualized instruction. Educators are cognizant of individual differences in students and realize the need for providing for these differences in the teaching and learning of science. It is recognized that students should be allowed to develop their own unique learning styles. On the other hand, the more conventional methods of teaching may not only tend to inhibit educational growth, but may also hinder personal development. Thus, there arises the need to individualize instruction.

The traditional approach of teaching science in America - that of teacher lecture, class discussion, and laboratory exercises - has assumed that all students with the proper effort are capable of achieving the same goals. Some educators feel that science programs employing traditional approaches have failed to meet the individual needs in that the low achiever learns practically nothing while the superior student learns little that he does not already know.

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Purpose of the Study

Individualization of instruction provides an educational environment that allows students to progress at a rate commensurate with their interests and abilities. However, research has shown that unless students are well organized and self-directed, they are unable to cope with this freedom. The primary purpose of this research study was to investigate the various characteristics of successful and less successful students and to determine what effect these characteristics have on achievement in an individualized learning program.

Sources of Data for the Study

In this study, an investigation has been made of students who were participating in an individualized self-paced biology program at Glenbrook North High School, Northbrook, Illinois during the 1973-1974 academic year. At Glenbrook North High School, flexible, workable, multimedia, individualized high school science courses have been developed for earth science, biology, and chemistry. These individualized learning science programs were implemented on a partial basis in the fall of 1970-1971 and on a full-time basis during the 1971-1972 school year.

Students enrolled in the individualized learning (IL) biology program receive a year of credit upon completing "contracts" for 34 learning units of material. The work rate and the responsibility for completion of the contracts to satisfy course requirements is left entirely to the student.

By actively participating in the learning contracts, students learn to accept the responsibility for their progression through the course. Students can theoretically learn on their own, completely independent of the teacher, by utilizing the IMC and by taking advantage of other learning resources such as the lecture tapes. Or, a student can maximize the use of the teacher by attending all of the presentations and by capitalizing on the teacher's personal attention that is available in a tape-and-help room. Instruction is individualized and personalized in terms of methods, achievement and pacing. The individual student determines those strategies and curricular devices that: (1) are tailored to his individual strengths, (2) are personally beneficial, and (3) will satisfy contract requirements.

Statement of the Problem

The purpose of this study was to investigate the characteristics of "high," "expected," and "low" achievers in an individualized biology program at Glenbrook North High School. The problem that arises is - What are the characteristics that differentiate the students who "do well" in an individualized program from those who "do not do well"?

The definition of this problem makes possible the identification of the primary question of this study, which can be stated as a single null hypothesis:

> There are no differences in student characteristics between "high" achievers, "expected" achievers, and "low" achievers in an individualized learning biology program with regard to the following variables: (1) personality, (2) motivation, (3) attitude toward science, (4) understandings about science, (5) critical thinking ability, and (6) scholastic aptitude.

The Instruments

In this study a total of 35 measures were collected for each individual by utilizing seven different psychometric inventories. Their descriptions are as follows.

Nelson Biology Test, Forms E and F.[1] A 65-item inventory developed to measure the understanding and ability necessary to apply knowledge and to interpret problem situations in biology. The test is designed to measure the knowledge of biological concepts and principles, the understandings of these concepts and principles, and the ability to interpret data and to draw conclusions.

Watson-Glaser Critical Thinking Appraisal (WGCTA), Form ZM.[2] A 100-item instrument designed to measure the ability to think critically. This instrument consists of five subtests, each designed to inventory a different but related aspect of critical thinking. The total score was used in this study.

Test on Understanding Science (TOUS), Form W.[3] A 60-item multiple choice inventory designed to measure understanding of science in the following areas: (1) the scientific enterprise, (2) the nature of scientists, and (3) the methods and aims of science.

Scientific Attitude Inventory.[4] A 60-item inventory providing a valid and reliable measure of scientific attitudes to be used at the secondary level. This instrument was utilized to inventory student's knowledge and feelings in four categories: (1) positive intellectual, (2) negative intellectual, (3) positive emotional, and (4) negative emotional. Students respond by agreeing or disagreeing to six types of position statements.

High School Personality Questionnaire (HSPQ), Form A.[5] A 140-item instrument that yields a general assessment of personality. This standardized test purports to measure personality traits that represent one's total personality. The descriptions of the 14 subscales of the HSPQ and their reliability and validity coefficients for Form A are given in Table 1.

School Motivation Analysis Test (SMAT), Form A, Research Edition.[6] A 190-item interest-motivational inventory purported to be related to achievement. This inventory is designed to measure ten independently derived motivational traits consisting of six ergs (drives, instincts, needs) and four sentiments (acquired attitude patterns, secondary drives). The dynamic traits measured are:

The Ergs (Drives)

1. Assertiveness
2. Mating
3. Fear, Escape
4. Narcism
5. Pugnacity-Sadism
6. Protectiveness

The Sentiments

7. Self-Sentiment
8. Superego
9. School
10. Home

Aptitude Measures. Scores on the Classification and Placement Examination (CAPE) were gather for all students. Utilization was made of (1) percentile scores of five of the CAPE subtests measuring general mental ability and scholastic achievement and (2) an aptitude score representing I.Q.

TABLE 1

SUBSCALE RELIABILITIES AND VALIDITIES

FOR THE HSPQ

HSPQ factor	Description		Reliability[1]	Validity[2]
	Low Score	High Score		
A	Reserved	Warmhearted	.85	.67
B	Less Intelligent	More Intelligent	.78	.69
C	Affected by Feelings	Emotionally Stable	.77	.71
D	Undemonstrative	Excitable	.80	.63
E	Obedient	Assertive	.74	.65
F	Sober	Enthusiastic	.76	.68
G	Disregards Rules	Conscientious	.72	.68
H	Shy	Adventurous	.81	.72
I	Tough-Minded	Tender-Minded	.88	.70
J	Zestful	Circumspect Individualism	.81	.58
O	Self-Assured	Apprehensive	.83	.77
Q_2	Sociable Group-Dependent	Self-Sufficient	.82	.61
Q_3	Uncontrolled	Controlled	.78	.57
Q_4	Relaxed	Tense	.84	.74

[1]Reliability coefficients of Form A based on test-retest after one day on three groups of 90 to 110 high school juniors.

[2]Construct validity coefficients of Form A based on 200 high school students.

Measurements collected from the CAFE were:

1. Verbal
2. Quantitative
3. Reading
4. Math
5. English
6. Aptitude (I.Q.) measurement

The data for this investigation were collected during the 1973-1974 academic school year. Data were collected during the first few months of the school year and again at the conclusion of the school year in June.

Statistical Analyses

The data of this investigation were subjected to a number of different analyses to answer the questions of this study. Utilizing all students (N = 406), a sample representing 25% of population (N = 100) was selected at random. By employing multiple regression analysis, data obtained from these 100 individuals were utilized in deriving a prediction equation in which achievement was used as the criterion measure.

In the multiple regression analysis, the scores of the Nelson Biology Pretest and the aptitude measure were used as the independent variables while the Nelson Biology Posttest was used as the dependent variable. Once the multiple regression coefficients had been generated, a "predicted" achievement score plus or minus the standard error of estimate was calculated at the .001 confidence limit for the remaining 306 individuals. Once these predicted scores had been calculated, those individuals who showed discrepancies between "predicted" achievement and "actual" achievement (Nelson

posttest) were designated "high" or "low" achievers. Those who did not show discrepancies were designated "expected" achievers. In this investigation 80 "high" achievers, 132 "expected" achievers and 94 "low" achievers were identified.

Differences in student characteristics were sought between the three achievement levels. The problem of maximizing differences between three or more groups on multiple measurements lends itself to a multivariate statistical technique known as discriminant function or discriminant analysis. This technique provides for a minimum of measures in maximizing group differences. Multiple discriminant analysis was then performed on 256 individuals with 50 cases set aside for cross validation. The purpose of the cross validation was to determine the efficacy of the discriminant function equation in correctly predicting group membership for unclassified individuals.

Multiple discriminate analysis between achievement levels (N = 256) was performed on the remaining 32 variables utilizing a version of the SPSS Discriminant Analysis routine at Vogelback Computer Center at Northwestern University. This subprogram generates linear functions which best seperate three or more groups in two main steps. First, the variables are selected in a stepwise manner employing the distance statistic known as Rao's V. Secondly, a canonical analysis is performed on the discriminant function to reduce them to a minimum number of independent functions. The criterion for the first variable selected is the one with the highest univariate F-ratio and Rao's V is calculated for that variable. The remaining

variables are then "searched"and the variable that adds the greatest amount to Rao's V when tested for significance by Wilks' lambda is selected for the next variable. This procedure was continued until 5 variables were selected.

Results of the Investigation.

Two discriminant functions were generated in this investigation. The results revealed that both functions (λ=.7890, λ = .9367 $p < .01$) significantly discriminated between "high," "expected," and "low" achievers and that all five variables contributed significantly in producing this separation (Tables 2 and 3). The Watson-Glaser Critical Appraisal (WGCTA) and Factor E (Obedient vs. Assertive) of the High School Personality Questionnaire (HSPQ) were the first two variables chosen and for both of these variables Wilks' lambda and Rao's V were significant at the .01 level. The third variable chosen was the Science Attitude Inventory (SAI). The last two variables selected were Factor 9 (Sentiments toward School) and Factor 8 (Superego) of the School Motivation Analysis Test (SMAT).

The standardized discriminant function coefficients (used for predicting unclassified individuals) are presented in Table 4. The group centroids of the "high," "expected," and "low" achievers in the reduced discriminant space are reported in Table 5 and are plotted in Figure 1. Table 6 reports the means and standard deviations for "high," "expected," and "low" achievers on the five variables.

TABLE 2

SUMMARY TABLE OF VARIABLES DISCRIMINATING BETWEEN HIGH, EXPECTED, AND LOW ACHIEVERS

Step	Variable Entered	Wilks' Lambda	Change in Rao's V
1	Watson-Glaser Critical Thinking Appraisal	.8749**	36.1921**
2	HSPQ - Factor E	.8305**	13.7319**
3	Science Attitude Inventory	.8133**	5.8318
4	SMAT - Factor 9	.7929**	7.4032*
5	SMAT - Factor 8	.7890**	5.6258

TABLE 3

SUMMARY TABLE OF DISCRIMINANT FUNCTIONS

Number Removed	Eigenvalue	Wilks' Lambda	Chi-Square	D. F.
0	.2043	.7890	63.33**	10
1	.0676	.9367	16.48**	4

*p<.05
**p<.01

TABLE 4

ORTHOGONAL DISCRIMINANT FUNCTION COEFFICIENTS

Variable	Lambda Weights 1	2
Watson-Glaser Critical Thinking Appraisal	.8449	-.0250
HSPQ - Factor E	.1302	-.8057
Science Attitude Inventory	.3259	.4060
SMAT - Factor 9	-.2841	.3289
SMAT - Factor 8	-.2869	- 2778

TABLE 5

CENTROIDS OF HIGH, EXPECTED, AND LOW ACHIEVERS IN THE REDUCED DISCRIMINANT SPACE

Achievement Levels	Centroids	
High Achievers	.1241	.4373
Expected Achievers	.3890	-.1893
Low Achievers	-.6535	-.0914

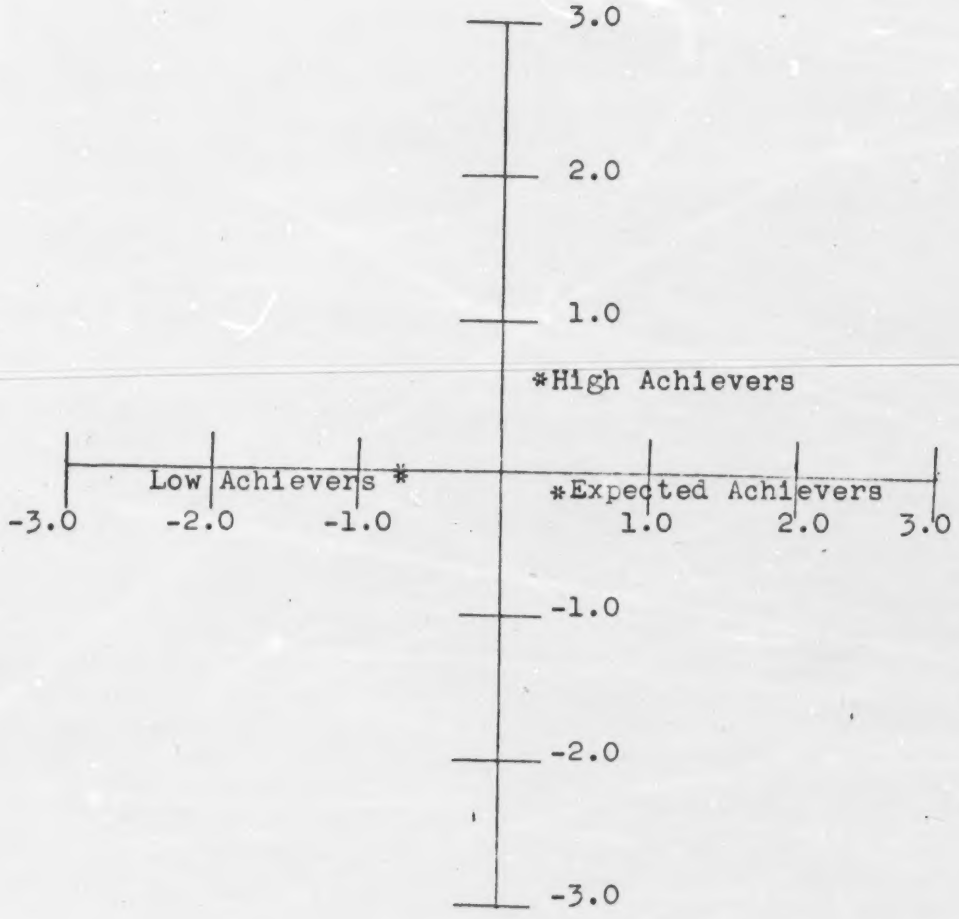

Figure 1

CENTROIDS OF HIGH, EXPECTED, AND LOW ACHIEVERS
PLOTTED IN THE REDUCED DISCRIMINANT SPACE

TABLE 6

MEANS AND STANDARD DEVIATIONS OF HIGH, EXPECTED, AND LOW ACHIEVERS

Variable	High Achievers N = 65 $\bar{X}$	S.D.	Expected Achievers N = 112 $\bar{X}$	S.D.	Low Achievers N = 79 $\bar{X}$	S.D.
WGCTA	58.86	6.96	60.08	9.73	52.67	8.25
HSPQ E	8.45	3.46	10.18	3.07	9.87	3.10
SAI	115.02	11.95	113.41	13.01	107.82	13.49
SMAT 9	21.25	3.46	20.50	3.63	21.15	3.47
SMAT 8	21.20	3.56	20.62	3.86	20.72	4.16

TABLE 7

CROSS VALIDATION

Achievement Level	Number of Individuals	Number Predicted Correctly	Percent Correct
High Achievers	15	3	20
Expected Achievers	20	13	65
Low Achievers	15	8	53
Total Number	50	24	48

To determine the efficacy of the discriminant function equations (N = 256), a cross validation was performed using the discriminant function prediction equation (orthogonal discriminant function coefficients) to predict the achievement classification level for the remaining individuals (N = 50). The results are reported in Table 7.

Discussion

The results revealed that the "high" and "expected" achievers had a significantly higher score on the WGCTA than the "low" achievers. This can be interpreted to mean that the "high" and "expected" achievers have a greater ability to think and analyze situations critically. In addition, the "high" and "expected" achievers had a higher mean score on the Science Attitude Inventory demonstrating that these students have manifested a more positive intellectual and emotional attitude toward science. It was also found that the "high" achievers had the lowest mean score on Factor E (Obedient vs. Assertive) of the HSPQ inventory. This can be interpreted to characterize the "high" achievers as being more accomodating and submissive while the "expected" and "low" achievers are more competitive, agressive and dominant in nature.

Differences on Sentiment Factors 8 and 9 of the SMAT inventory again favored the "high" achievers, but only slightly. Factor 8 (Superego) purports to be a measure of the superego with a higher score representing a drive for positive and moral achievement. It was found that the "high" achievers also had

the highest mean score on Facor 9 (Sentiments toward School). This subscale represents a measure of the students' interest in school activites, particularly emphasizing scholastic and classroom interests. It must be pointed out that mean scores on these last two variables are very close to one another, but when taken as a battery, all the variables together produce a significant discrimination between "high," "expected," and "low" achievers with a minimum amount of overlap.

In determining the efficiacy of the discriminant function equations, a cross validation was performed. The results revealed that a considerable amount of shrinkage did take place as the percentage of correct predictions ranged from 20% correct for the "high" achievers to 65% correct for the "expected" achievers. These results indicate that significant discrimination can be obtained in separating "high," "expected," and "low" achievers but that some caution should be exercised when using these discriminant function coefficients for predictive purposes.

Conclusion

On the basis of the findings, it is possible to reject the null hypothesis and to conclude that significant differences do exist between "high," "expected," and "low" achievers in an individualized high school biology program. A battery of five variables revealed a significant discrimination between achievement levels on the following factors: (1) the ability to think critically, (2) Obedient vs. Assertive, (3) attitude toward science, (4) Superego, and (5) Sentiments toward School.

The findings of this investigation tend to support the results of previous research studies on individualization. Successful students are those who have a high interest and positive attitude toward science and school activities. Aptitude, attitude, personality, and motivation all contribute toward determining the achievement of a given student in an individualized program.

A crucial and important question to consider and discuss at this point is - Which of these characteristics seem to have the greatest effect and influence in determining the achievement status of a given individual? The present investigation seems to demonstrate that individuals who are interested and motivated will at least perform as expected in an individualized program.

In a program that is self-paced, the ultimate responsibility for the completion and passing of course requirements is left entirely to the student. The ultimate factors which appear to determine success are not knowledge, but instead are attitude and motivation. If a student has a poor attitude toward science and is not motivated, regardless of his prior knowledge, he is likely to do poorly in an individualized setting. The same factors can be argued for the lack of success in a traditional course, but these two factors of interest and motivation seem to be of more importance in a self-paced individualized science program where the decisions and responsibilities are placed into the hands of the learner.

The students who have difficulty with an individualized self-paced program are those who are simply not motivated or interested. This factor seems to be true regardless of the academic ability or potential that the students possess. If the students are not interested, motivated, or hate science, they do not accept the responsibility for meeting and completing course requirements. These students either end up with low grades or they have extreme difficulty im completing the course.

This study has shown that student characteristics are related to cognitive achievement in an individualized high school biology program. The reasons are multiple and complex. It is not necessarily known why these differences do exist, but it is obvious that differences in cognitive achievement do exist. Herein lies the major implications of this investigation, because this information can be put to use concerning the future placement of students in an individualized self-paced program.

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For a greater description of this investigation, consult either of the following two sources:

Littlefield, David L. 1974. "An Investigation of Student Characteristics as Related to Achievement in an Individualized High School Biology Program." Unpublished Doctoral Dissertation, Northwestern University.

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